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The Structure of Chinese Motorcycle Industry and the Strategies of Japanese Companies*

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1. Introduction

This article aims to clarify the situation of product architecture changes in the motorcycle industry in China, and to present the explanation for the relationship between the change and the strategic response of existing firms, especially of Japanese motorcycle makers.

In the industries with established technology hierarchy, we sometimes observe that changes in fundamental technology dramatically transform the conditions for competition in the industry. These changes in technology do not always occur in the explicit forms which can be handled by competing companies. Rather, it is often the case that technology change occurs as new customers emerge whose standards of evaluation differ from those of existing customers, while companies are not able to recognize the favorable prospects these changes may have (Christensen and Bower, 1996). While not being recognized as evident technology changes, some changes may in fact progress, to which existing companies might find difficult to adapt to. Changes in "product architecture" which represents the relationship between parts that constitute a product system fall under this type of change (Henderson and Clark, 1990; Fine, 1998). Although frequently not recognized as technological change, such changes do have a great impact on companies' competitiveness, since they may incur organizational obstacles in product development.

The innovation of such new technology and the form of division of labor are often accompanied by the formation of national or regional industrial clusters, which are managed by a group of companies that are regionally isolated strategic groups (Porter, 1990). In the examples of the shift from vacuum tubes to transistors in color televisions and the shift from a mechanical system to a quartz system in the watch industry, the

* This article draws extensively from Otahara, Sugiyama and Fujimoto (2003). The research is a part of the study in progress sponsored by International Motor Vehicle Program (IMVP) at Massachusetts Institute of Technology (MIT).

technology changes were initiated by the group of companies in the industrial clusters of Japan (Shintaku, 1994). Clusters play a significant role in the emergence of new technology and products as well as the transformation of existing companies. The purpose of this article is to analyze the case in which changes in product architectures were not conducted by the existing prominent companies but by the companies constituting a cluster.

The motorcycle industry can be mentioned as one example of the cases in which changes in product architectures are attributed to the achievement of the group of companies belonging to diverse clusters. Since mid-20th century, Japanese companies connected motorcycle production with a mass production method and has replaced European ones as an important supplier of motorcycles in the expanding international market. Half a century later, in the latter half of 1990s, Chinese companies started motorcycle production in a massive scale. Their entry did not only meet the domestic needs but also made an entry into the export market. The industrial organization, technology, and modality of division of labor of the motorcycle industry in China so far appear different from those developed in Japan. It is considered that this can be one of the factors contributing to the reversal of competitiveness between Japan and China in specific market segments.

In the following chapter, we would like to give a brief explanation of product architecture and cluster, the concepts of primary significance in this article. Next, we will focus on the change in product architectures in the motorcycle industry and describe the situation. In particular, the characteristics of the product architecture change in progress in China will be delineated, and the relationship between the change and the competitiveness of the industry will be mentioned. Next, the situation related to the change which is unique to China will be described, and a hypothetical explanation regarding the relationship between architectures and clusters will be presented. Finally, we describe the recent change of the strategy of Japanese makers, such as Honda, Yamaha and Suzuki to figure out the response of existing firms to the situation. The description pertaining to the Chinese motorcycle industry is derived from the field study in China conducted in the summer 2001, as well as from the previous studies[1].

[1] The field study was originally conducted as a part of the research project of IMVP led by Prof. Takahiro Fujimoto, University of Tokyo.

2. Changes in Product Architectures and Clusters

2-1 What is Product Architecture?

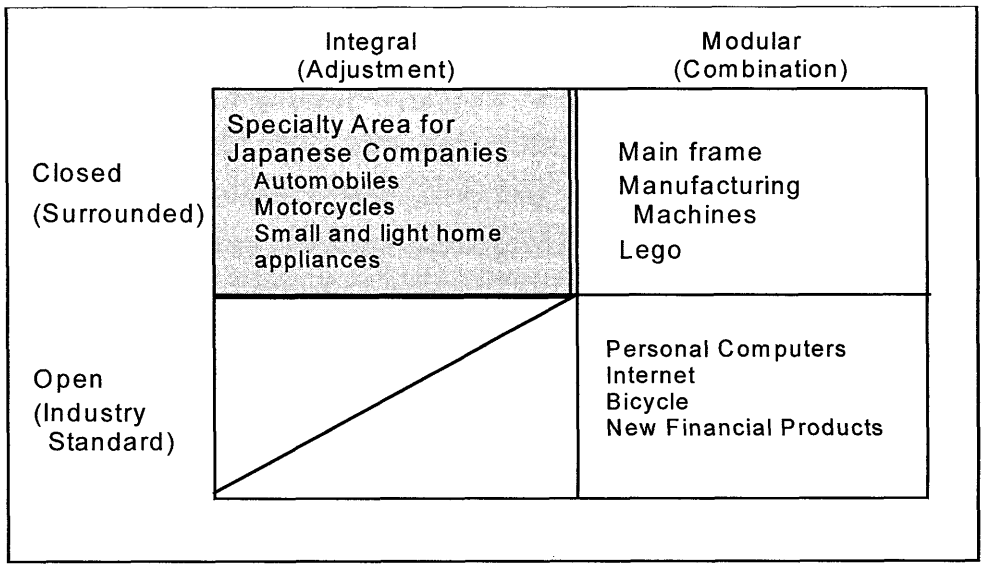
Let us begin with the definition of the key concept in this article, product architecture, before getting into discussion. In general, architecture is a concept that describes the nature of system and is described by the pattern of interdependent relationships among components that constitute the system (Baldwin and Clark, 1997). Regarding a product as a system consisting of components or parts, product architecture delineates the pattern of interdependent relationships among the components. More concretely, we can define it as "the basic design philosophy pertaining to 'the ways in which a product can be divided into components and processes, product functions can be allocated to each component and process, and how the interface between components that become necessary by these divisions and allocations should be designed and adjusted' (Fujimoto, 2001)".

The classification of product architectures is typically seized with the combination of the following two conceptual axes. The first axis represents the differentiation between "modular" and "integral"; the former is the type in which function and component have a one to one correspondence and each component has self-contained function, whereas the latter refers to the type of architecture in which function and component do not have a one to one correspondence and one part may bear multiple functions (Ulrich, 1995).

As the degree of functional and structural interdependence among parts is low in modular type products, they do not require much information exchange and their interfaces can be made relatively simple. Therefore, it is considered that products with the design of combining modules can demonstrate sufficiently high performance as a whole product. This is due to the fact that the adjustment among modules necessary for product development is embedded, which substitutes ex-post adjustment by controllers. On the other hand, the designers of each module are closely affiliated to make minute adjustments among each design for integral types (Fujimoto, 2001). With modular architecture, companies acquire values by pursuing flexibility and the speed of technological change by replacing modules, in contrast to the case of integral architecture, with which companies pursue higher values by making subtle adjustments in the system as a whole by customizing designs, or replacing the whole system at a stretch.

The two classifications of "open" and "closed" are added to the above axis as the second axis. "Open" refers to the cases where interface among parts is standardized

Figure 1 Classification of Product Architecture



Source: Fujimoto (2001), p.6, modified by the author

across companies on the industry level, whereas with "closed" architecture, interface among parts is limited within the company. These two axes allow the classification into 4 different types. For example, if we look at the type of industry which assembles parts, integral types have high affinity with close types, and modular types, with open types, respectively. The companies which adopt integral architectures often find it necessary to make minute adjustments with parts suppliers. That tends to make them the "*keiretsu*" companies. On the contrary, those which adopt modular architectures usually keep suppliers at arm's length and the relationship tends to be more open. This is because the standardization of interfaces enables the companies to replace suppliers with a relative ease.

Among the 4 types, closed / integral type is considered to be the area in which the Japanese companies have historically shown strength in (Fujimoto, 2001). The typical examples are automobiles and small-sized light-weight home alliances. The basic design of motorcycles, the subject of this article, had also been mostly closed / integral type, from the time when the Japanese companies had shown a rapid growth to the beginning of the 1990s.

2-2 Dynamics of Product Architectures and Clusters

While we have stated that each industry has a different trend of product architectures, this does not mean that product architectures are the given matters for industries or companies. Rather, from a historical point of view, product architectures

tend to show cyclical changes between modular and integral (Fine, 1998). In the industries where integral architecture is dominant, the strategic adoption of modular architecture generates the opportunities for profits. Similarly, while it is true that there is a trend of architectures unique to the industry when modular architectures are predominant, the trend itself is subject to change in the process of the industrial progression.

On the other hand, it should be noted that dominant architectures have the lock-in effect. The system of technology tends to be kept continuously in the same mode. Henderson and Clark (1990) indicated the tendency that the cognitive frameworks and communication structures of the organizational members of companies stiffen reflecting the adopted architectures, which may prevent them from receiving information outside the routine channels. As Sanchez and Mahoney (1996) noted, Product architecture provides the way of problem-solving in product development process, which constraints the pattern of intra- and inter-firm organization. As a result, the forms of organizations tend to be of the same shape as the architecture of their products. The intra- and inter-firm organizations that are formed in such manners, adapting to the existing architectures, become the obstacles against changes when product architectures must be changed. It is therefore possible that a great trigger must be present for the industry as a whole to change.

The growth and development of the companies based in different national clusters represent one of the patterns of such great trigger. In many industries, as suggested by Porter (1990), related and supporting industries, competing companies, markets for advanced products, and labor markets specific to the industry are likely to concentrate in one region to different extents, and this agglomeration is called cluster. Due to the reasons stated below, the companies belonging to different clusters tend to become the destroyers of architectures, or initiate the changes in architectures, as the companies belonging to a cluster as a whole can easily be locked in certain architectures.

There are two reasons why architectures within a cluster stiffen so easily. One is the short-sightedness in imitating and learning behaviors. Despite being competitors, companies belonging to the same cluster can be regarded to have a kind of harmonized relationship, in a sense that they learn from each other by observing the reactions from product markets. In such circumstances, the companies are likely to be pressured to imitate the competitors' strategies, often leading to the identical patterns of the corporate relationships among parts suppliers. The subjects of the imitations and learning behaviors as such tend to be the companies belonging to the same strategic group. This is attributed to the local nature of the exploratory activities of the

companies in their learning.

The other reason can be derived from the network effect among related and supporting companies. In other words, the architectures adopted by first mover companies can be a significant restrictive factor for new entrants or follower companies that affects the possibility for selecting product architectures. In order for the follower companies to enjoy the merits of belonging to the same cluster, they need to utilize the existing resources in related and supporting companies. For this to happen, however, it is highly likely that they are required of adapting to the dominant modalities among existing suppliers. For example, the suppliers which have only dealt with modular architectures do not probably accept the minute adjustments among companies to actualize integral architectures, while it is considered that the suppliers who have frequently dealt with integral architectures are likely to avoid the business patterns in which they could not exert their accumulated corporate strength such as the knowledge in products as a whole and the complex systems for dealings among companies.

For these reasons, it is often the case in many industries that new product architectures are introduced by a group of companies based in different countries. The product architectures in the industrial history of motorcycles have gone through major changes, each time primary production location was changed across countries. The shift from more open / modular product architectures in the first half of the century, the peak time for European makers, to more closed / integral architectures is observed as the primary production location transfers to Japan. Nevertheless, since the mid-1990s, when China started to replace Japan as the primary production location, the product architecture again becomes more modular. This modular type of architecture in China is not the same as the one in Europe before, differing significantly in technology and the form of division of labor.

Thus, the changes in product architectures in the motorcycle industry have driven by the companies that belong to different clusters. In other words, the changes in dominant product architectures were initiated by the strategic groups of companies delineated by the national boundaries such as Japan and China. In the following, we will examine the changes in architectures in the motorcycle industry, taking note of the dominant product architecture in the industry, the affecting factors of the nation or region to product architectures, as well as the influence product architectures exert.

3. Change in Product Architectures in the Motorcycle Industry

3-1 Transition of Product Architectures in the History of Motorcycle Industry.

Similar to the automobiles before the time of Ford model-T, the motorcycles which came into existence in the beginning of the 20th century had the product architecture of what should be called "coarse modular" type. In other words, there were many specialized manufacturers which supply components such as engines, bodies, and carburetors, and the motorcycle manufacturers designed their products on the assumption of the use of these components available in the market. In many cases, the motorcycle makers only combined and assembled the general-use components with minor modifications if any, which was conducted by craftsmen using files. The scale of such companies was usually tiny, mostly smaller than the major suppliers (Demizu, 1991; Koerner, 1995).

The Japanese motorcycle industry started as the industry with the architectures of "coarse modular" in the first half of the 1950s, but with the introduction of "Super Cub" in 1958, it shifted its product architecture to the integral type, similar to or more than that of the automobile industry. Most of the components constituting Super Cub were designed specifically to the product, which was not compatible with the products of other companies or the previous products of Honda. The parts suppliers, those which were committed to the prospects of Honda and Super Cub, not only made investments to the dies and production lines specially made for the product. They but also decided the construction of plants near the Suzuka Plant in Mie Prefecture, which was constructed for the mass production of Super Cub (Honda Motor Suzuka Plant, 1987). With this momentum, the scope of parts purchasing in Honda which had been wide was narrowed down, resulting in a rapid increase of the dealing volume and value per company. Super cub turned out to be a great success, and its production volume reached 50,000 per month, surpassing that of the previous models by 10 times. The domestic market share of Honda exceeded 60% in the first half of the 1960s, accelerating the selection of small to mid-sized motorcycle makers. As the major players in the related field such as Yamaha, Suzuki and Kawasaki followed the path of Honda, the industry which had been characterized by modular and open deals transformed to the industry characterized by the optimized design for each model and relatively closed supplier relations (closed / integral type of architecture) (Otahara, 2000). These four companies competed to demonstrate their superiority of the devised design philosophy by winning the international races. Having incorporated the feedback from such efforts, the Japanese motorcycles gradually dominated the world market in line with the change in

the form of demand in advanced markets, from the basic means of transportation to the instrument for recreation. Their success culminated in the 1980s.

In the latter half of the 1990s, however, the production volume of motorcycles in China reached over half the total in the world, outdoing Japan. Furthermore, the dominant product architecture in the Chinese motorcycle industry returned to the open structure as before. In the domestic market of over 10 million per year, the number of the officially registered companies only amounted to 140, and together with the other "underground plants," the market was said to be crowded with motorcycle makers of over 600 (Ohara, 2001). Nevertheless, these companies had been producing the motorcycles that were almost identical and could not be discriminated from one another. This applied not only to the appearance but also to the compatibility of the parts in use. This similarity is attributed to the fact that most of the motorcycles are modeled after CG125, which Honda developed in the latter half of the 1970s for the markets of developing countries.

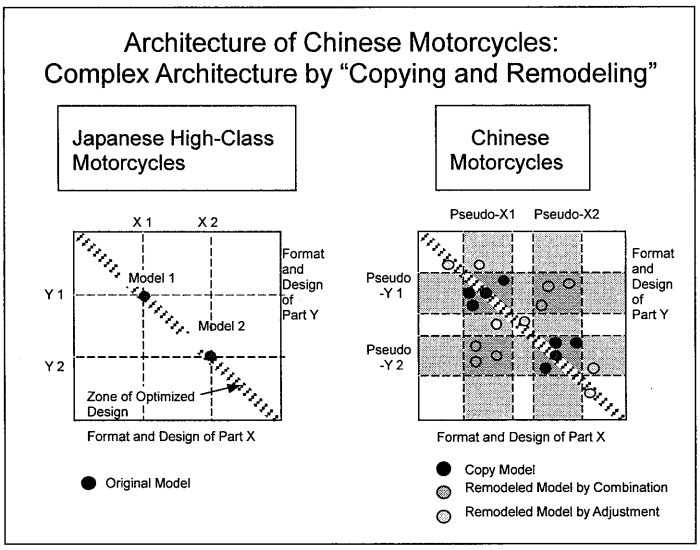
Having learned a lesson from the failure of the high-performance, sports models in the markets of developing countries, CG125 was designed to fit the restrictive conditions of the market, reflecting the environment for usage and maintenance (Honda R&D, 1998). The model has been introduced in the Chinese market since the 1980s, at which time it was produced at Jialing Motors, technologically affiliated with Honda. In China, there was a regulation for the control of technology introduction contract which ruled out the prohibition of keep using the technology after the termination of contract, which was given through technology affiliation. Under this regulation, Honda could not control the intellectual property right regarding CG125 after the termination of its technology affiliation. Among the variety of models produced by the Japanese makers through technological affiliation or joint ventures, the model was the most popular and highly reputed. Nevertheless, the product registration system at Tianjin Motorcycle Research Center, directed by the Chinese government, required Honda to register and make public the specification and design drawings of the model, which was then widely transmitted across the nation under the technological guidance of Tianjin Motorcycle Research Center. In the 1990s, the design drawings of a variety of parts called "CG type" including engines, bodies and carburetors were already shared among the public and private sectors as if they were the public property.

In the latter half of the 1990s, the firms' entry into the motorcycle market accelerated along with the boosting demand for motorcycles in urban areas reflecting the higher income. Most of the entrants were small to mid-sized private makers, which were supported by the suppliers of the "CG type" parts and components which showed a

rapid increase hand in hand with the remarkable improvement in the level of mechanical processing technology. To manufacture motorcycles, it was just as easy to order the CG type parts in the suppliers' catalogue and assemble them. Therefore the hurdles to enter the motorcycle assembling business were low. On the other hand, as long as the jumbling assembling makers produced CG type models, the suppliers were able to grow independently without relying on specific makers. To limit the produced model to CG type was a reasonable choice for both assembling makers and suppliers as long as their sales went well. By the mass production of the standardized parts, the costs continued to fall to 30% to 50% of Honda's original CG125, lowering the sales price of the Chinese motorcycles.

While the suppliers made changes from original CG125 in some areas such as displacement of engine or materials, the changes were just in the areas where minor changes suffice. Besides, in order to increase the variety, they listed in their catalogues other types of parts modeling such companies like Suzuki and Yamaha. Enjoying the benefit from low-price standardized parts, the assembling makers were able to double their product lineup through such combination of a variety of parts in their steady endeavors to attain differentiation, departing from the simple copied model of CG125. In this respect, the situation for the Chinese motorcycle industry was similar to the one for modular products which entail open business dealings. Although they did not simply load the Suzuki type bodies with CG type engines, they could almost do so with minor processing.

Figure 2. Product Architecture of the Chinese Motorcycles



Source: Composed by author based on the field hearing survey

Considering the level of the optimized designs the original boasted, however, their performance remained inferior. Moreover, as the simple combination of the parts for different models was not possible and the designs required modifications, it was necessary for them to acquire technical expertise in design. In this regard, their product architectures were something that should be called "quasi open" or "quasi modular." In the following, the product architectures of the Chinese motorcycle industry are analyzed with a greater precision and the implication for the competitiveness is to be considered.

3-2 Characteristics of Product Architecture in the Chinese Motorcycle Industry

As we analyzed the quasi-open, quasi-modular architectures in the Chinese motorcycle industry with a higher accuracy, it became apparent that three types of simple copy model, remodeled model by combination, and remodeled model by adjustment coexisted, as illustrated in the right part of Figure 2. Suppose that there are part X1 (for example, 50cc engine), X2 (such as 125cc engine), body Y1 (such as Cub-type body), and Y2 (Cub-type body), in the case of the Japanese original, as illustrated in the left part of Figure 2, both the 50cc and 125 cc engines are designed especially for the model, as integral parts to the CG type bodies. The parameters of each part are set optimally as integral parts from the designing stage, and no other combination exists. On the contrary, in the case of Chinese motorcycles, the situation is more complex as in the right part of Figure 2. There are at least three types of copy model, remodeled model by combination and remodeled model by adjustment, each of which occupies a separate location around the zone of optimized design of the original, represented by the diagonal line starting from the upper left corner. In the following, we will describe this phenomenon in order.

The left half of Figure 3-1 shows that the affluent copy models that fall behind the original model in accuracy of replication are distributed "neighborhood" to the original. The "neighborhood" indicates that they have not reached the quality level of the Japanese originals which are optimally designed. Nonetheless, the right graph of Figure 3-2 illustrates the actual situation that the parts within a certain range of quality and accuracy in light of the standards of the original parts (i.e., pseudo X or Y parts) are approved by the national government as "CG type" standard parts. The deep colored area contains the copy motorcycles composed of "pseudo parts" centering on the original, and everything within this area is called "CG type" in China. It is certainly possible for the copy motorcycles to be located in the diagonal zone just as the originals, if they could be made identical to the originals in terms of sizes, quality and the accuracy of assembling. To this date, however, such motorcycles have not been observed in reality.

Figure 3-1

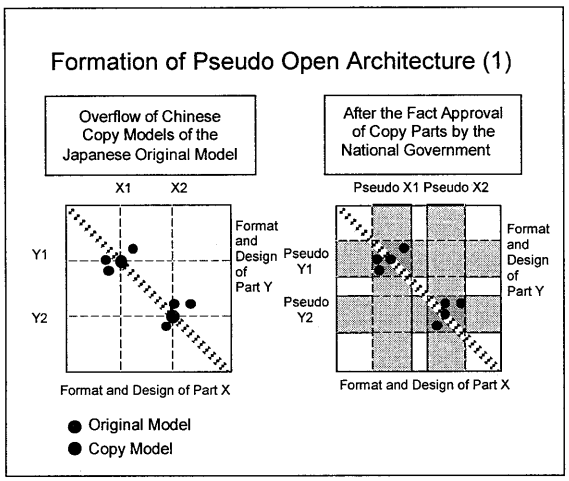
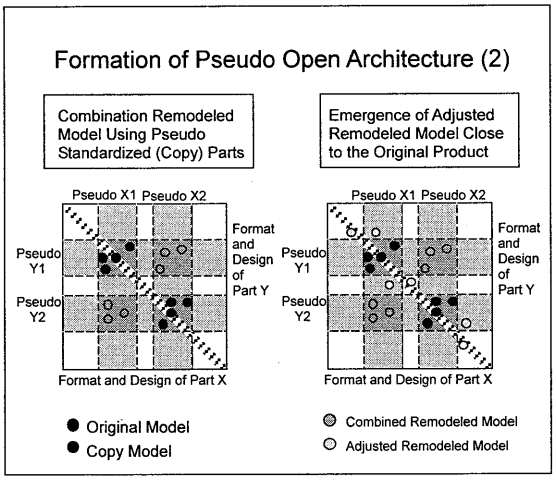


Figure 3-2



Source: Composed by author based on the field hearing survey

The left part of Figure 3-2 illustrates the situation that the "pseudo parts" which had constituted the copy motorcycles are combined now with other "pseudo parts" in a manner of permutation and combination, departing from the combination in the originals (plotted with gray circles). For examples, the combination of pseudo X1 and pseudo Y2 means that the 50cc engine which is originally supposed to be installed in Cub type is actually installed in CG type bodies, and similarly, the combination of pseudo X2 and pseudo Y1 means that the 125cc engine which is originally designed for CG types is installed in Cub type bodies. Such combinations occurred not only between engines and bodies that come from the same maker, but also across different makers, such as between pseudo Honda parts and pseudo Yamaha parts, or between pseudo Yamaha and pseudo Suzuki. We will call the motorcycles assembled by the combination that differs from the original "combination remodeled model" to differentiate them from the copy motorcycles.

The copy motorcycles present in the right chart of Figure 3-2, plotted with light grey, are the type which are not manufactured by simple scratch combination of pseudo parts procured from suppliers, but are made with the parts that are designed optimally for each model and are ordered to suppliers based on design drawings, despite that they are neighborhood of the original. In this article, this type is called "adjusted remodeled model." The reason why the adjusted remodeled models continue to be the neighborhood to the originals can be attributed to the following two points; The assembling makers have not gained the capability for unique designing, departing largely from the Japanese motorcycles, and in supplier relationship, they have not established the rule

of transaction to let suppliers invest in production facilities and dies of the custom parts at ease. Nevertheless, the Chinese makers have somehow or other declared to embrace unique designs. Besides, no matter how minor the modification may be, they demand the suppliers to provide the parts with integrally optimized designs, using standard parts as the base. These facts suggest the presence of their motivation to develop the Chinese original motorcycles, while modeling after the Japanese originals. In fact, some of the Chinese makers which develop and produce the adjusted remodeled models have already come up with the models with the additional functions which cannot be found in the Japanese originals (for example, the additional cell motors, gold-coating within cylinders, adoption of DOHC).

If we look more closely at the supplier relations, they have formed the subtle relationships which cannot be labeled as open or closed, reflecting the complex architecture. As for the supplier relations of motorcycles which had been considered as the typical closed / integral product, the Japanese makers usually give the suppliers detailed instructions in regards to functions, forms and materials. In contrast, the prior consent regarding the type of parts to be dealt has been emerged in China, which is the parts "neighborhood to CG type," due primarily to the overflow of the copy models of Honda's CG. Therefore, in their relationships, they could grasp the forms or functions if they glance at the specifications.

In the supplier relations of the present Chinese motorcycle industry, most customers provide the suppliers with the note of specifications, even if the parts ordered were the general purpose parts enlisted in the catalogue. The note of specifications provides the design drawings which even include the instructions for the minor modification of sizes, locations of holes, materials or production process. Although to a very limited extent, ex-post operations for integration are actually conducted. It is true that the parts and designs are more standardized across different assembling makers in the Chinese motorcycle industry, compared to Japan, Europe or North America. However, the industry has not realized the standardization of the interfaces among parts on the industry level, which has been observed with the personal computer or component stereo appliance businesses. At the least, national and private major makers have submitted the request for unique specifications to parts suppliers. In some case, they indicate the demand for "integration" aiming at the high level of performance.

Therefore, the role of catalogues have so far remained as just "putting up of flag" assuming that the after the fact exchange of the note of specifications follows. In other words, each supplier gives the signal that they are prepared to customize them within a certain range (which is often expressed as "tailor-made") by presenting the list of the

parts capable to produce.

Thus, the independent suppliers such as the ones called "catalogue parts makers" are capable of defining the structure of products and the interfaces among parts prior to the deals, which contributes to make the supplier relations open. In the present situation, their relations cannot be completed with just spot transactions and are complemented by the exchange of information through design drawings, the integration process within a narrow range. However, compared with the supplier relations in Japan, the extent of information exchange is limited and that saves a significant amount of procedural work.

3-3. Complex Architectures and Competitiveness

Next, the characteristics of the complex architectures which came into existence in China will be briefly described from the view point of both strength and weakness. The strength is their price competitiveness. All of the copies, combination remodeled models, and adjusted remodeled models are sold at the prices which is 30% to 50% of the original models. Since 1997 around which time the complex product architectures became dominant, the market share of the Japan-China joint ventures which had closed / integral product architectures continued to fall. Honda previously marked over 20% market share, which fell down to 6% in 2000.

The factors pertaining to the architectures were certainly not the only reasons for the low prices. Yet, it should be noted that they have realized a situation closed to single-model production by having eliminated the need for parts suppliers to consider the extensive modification of designs. With the stability of dominant designs and the national approval of the components as quasi standard parts, many Chinese parts suppliers have developed independently without relying on specific assembling makers. As long as the required modification was within the range of complex architectures, they are capable of supplying parts to a plural number of assembling makers without extensive modification of their facilities. This leads to the suppression of costs.

For instance, there are mega suppliers of which the annual production capacities are as large as 5 million in pistons, 3 million in carburetors, or 5 million in engine. In addition, most of the parts produced by these suppliers fall into the category of quasi standard parts, namely CG types. These quasi standard parts are sometimes sold as the parts for assembly makers in ten thousand lots, and sold at other times in one piece as repair parts. The unit price of the repair parts is set at the level which is just 10% higher than the price of the assembling parts sold in large lots. If this is the case, it should be possible for a tiny assembling company to enter and compete in the market

with sufficient price competitiveness, considering the low fixed costs and exemption of tax, as long as they assemble vehicles that can be regarded as motorcycles. Actually, the entry of so-called township and village enterprises in the rural region which engages in assembling of such repair parts has been suppressing the prices of motorcycles in the market as a whole.

On the other hand, what could be considered as the weakness of complex architectures is the difficulty to invest in the models whose designs are differentiated. Originally, in open / modular architectures, the interdependent relationships among parts are concentrated in the interfaces, which open up the opportunity for many companies to openly engage in technological development. In the situation of the Chinese motorcycle industry based on quasi open / modular architectures, however, its structure prevents major deviations from existing designs, limiting the designs to the neighborhood to the original models. The industry as a whole is locked in the standardized designs, indicating the limited possibility for the development of the Chinese original models which require major change in designs in the future.

4. Interactions between Clusters and Product Architectures

As explained in the previous chapter, the product architectures which have been formed in China differ from the ones dominant in the previous motorcycle industry. Thus, the relationship between the clusters and the changes in product architectures is considered and discussed in this chapter.

First of all, in regards to the influence of industrial clusters on the emergence of complex architectures stated in the previous chapter, two factors should be pointed out relating to policies. The first is the influence of the national policies of China promoting the spill over of technology. In the technological affiliations in China in the 1980s, there was the regulation for the control of technology introduction contract which ruled out the prohibition of the use of technology that was given through technological affiliation after the termination of contract. Therefore, the technology transferred through the affiliation was available for the recipient company to use freely after its termination. For the companies which affiliate with the Chinese companies, on the other hand, it was hardly expectable to be able to keep the technology appropriable. For example, Honda could not control the intellectual property right pertaining to CG125 after the termination of technological affiliation.

Furthermore, the product registration system at Tianjin Motorcycle Research

Center required the design drawings of all the parts including engines, bodies and carburetors to be registered. The specifications and design drawings of the Japanese makers such as Honda and Yamaha were accepted as the "model" technology and widely diffused through technological guidance. This led to the diffusion of the technological knowledge fixed to a few models such as CG125, while on the other hand, the technology was not updated frequently by the makers, resulting in the development of production capability without much introduction of new technology. This is considered to constitute the trigger for the development of the unique architecture by the Chinese makers.

Besides, in the 1990s, many suppliers started their operation to provide CG type parts in the market, which made it easier to introduce the products similar to competitors, which undoubtedly led to the intensive price competition among numerous makers. As incompetent makers introduced similar models using quasi standard parts, the market fell into the price-cutting competition using independent suppliers of mass production type.

Another factor related to policies is the influence of the number plate restriction in urban areas. In the latter half of the 1990s, the municipal government of each provincial city has restricted number plate issues for motorcycles at a certain level in the purpose of safety and environmental preservation. As a result, the acquisition of new motorcycles became extremely difficult in urban areas. The number of cities where the number restriction was administered stood at 30 at the end of 1998, which climbed to 97 by April 2001. Starting from the coastal areas, and towards the inland areas, there was an explosive expansion of the areas where the restriction was adopted. This resulted in the remarkable diminishment of the customer population who are relatively wealthy and demanding, having the product knowledge of motorcycles, which in turn prevented the expansion of the market share of the joint-venture companies with Japanese parents such as Honda, helping the Chinese architectures to rise to the dominant position.

The stability of the dominant design as well as the supply of quasi standard parts by independent parts suppliers supported by the stability itself contributed to the mass production of similar models resembling CG125 at low cost. Nevertheless, it raised the hurdle for model change and technological innovation, and therefore it is likely to lead to a dead end from the perspective of technological development. Yet, the focus of competition continues to be the prices as a result of the number plate restriction. Together with the situation in which the market growth is expected to expand at least for a while towards the rural areas where prices again are the focal factor in competition, it is reasonable that the existing complex product architectures are

maintained.

In addition to the influence of these official systems, we should note the phenomenon in which unofficial systems are preventing the reversal of architectures. The supplier relations in China have been constituted by co-evolution with architectures. Once the form of the supplier relations is established, which differs from the one seen in Japan, this turns into a restrictive factor on the changes in architectures, preventing the reversal back to the integral architectures.

In the Japanese automobile industry, the dominant pattern is that more design information can be located at assembling makers that place orders, and suppliers process the parts to fit the detailed chart and deliver to the makers. In the Chinese motorcycle industry, on the contrary, many of the components are made into catalogue-listed parts by suppliers in advance, and assembling makers place orders in the form of catalogue numbers. There is in fact some variation in the process, from the case in which makers purchase the parts just as listed in the catalogue, to the case in which they demand minor modification although the specification is mostly unchanged from what is enlisted in the catalogue. However, in any case, it is hardly found that assembling makers request the designs largely deviating form the catalogue-listed parts or they design totally new parts and place orders with the suppliers.

According to Ohara (2001), it is generally observed in China that assembling makers sometimes refuse to take on the whole of ordered and contracted volume from suppliers, or sometimes change the suppliers for the parts which have already been contracted with other suppliers. If this is the case, it incurs a significant risk for the suppliers, and it should be more rational for the suppliers to make their product lineups applicable to as many commodities as possible so that they can resell them. The production of custom parts based on the novel design drawings submitted by specific assembling makers is avoided as it requires investment in dies or production facilities and the risk becomes too high. Such structure of transactions becomes a rational choice only when the deals are maintained at least during the contract period and the loss incurred by the excessive ordered and contracted volume is compensated for by assembling makers. As long as the form of transactions is such that the risk is born only by the suppliers, the lock-in to quasi standard parts is to continue and complete vehicles are to hover around the approximation of CG, which is a dominant design.

5. Strategies of the Japanese Makers

In order to cope with the situations where such quasi-open architectures dominate, the Japanese companies have demonstrated a shift in their strategies to the one which places China as the base to create competitive advantage. In other words, they are trying to transform their organizational systems to take advantage of the characteristics of quasi-open architectures by localizing the activities of product development and procurement, and thereby acquiring more information sticky to the local environment.

The Japanese makers have taken various measures to make the local foothold the base to create competitive advantage. Honda is aiming to make effective use of the industrial clusters in China through the alliance with the Chinese private makers as well as the establishment of the R&D center. As a counterpart of the alliance, Honda chose Sundiro based in Hainan province, often ridiculed as a Honda's imitation maker, and together established the joint-venture, Sundiro Honda Motorcycle. The company thus showed a dramatic change in its strategy to be allied with the Chinese makers, which had been the natural enemies for the Japanese makers as the producers of its imitation motorcycles.

The purpose of the above move lies in the utilization of local suppliers, to acquire the know-how for cheap production. Mr. Kentaro Kato, the managing director and the executive manager of motorcycle business at Honda, states as follows.

"In China, the number of motorcycle makers reaches 150 for major ones alone, and 500 in total, causing fierce competition. With their strength in price, they are rapidly expanding the business overseas. They remind me of Honda in the old days, challenging and speedy. The talks about the joint-venture have been there for two years, and we will together enhance our competitiveness with the synergic effect between their strength and Honda's brand name. We will acquire the know-how for cheap production. Honda is the only one that knows the key points in managing local copy parts. It is Honda that is capable of producing the best copy complete models[2]."

In parallel to the above, Honda is also to establish the R&D center in China. In January 2002, the company announced to establish the Honda Motorcycle R&D China Co., Ltd., the local entity which engages in R&D of motorcycles for the Chinese domestic market[3]. The purpose of the establishment of the R&D center is to adopt the Chinese standards of quality and to utilize local suppliers following the standards. Regarding

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[2] *Shukan Toyo Keizai*, December 15, 2001, p.35.
[3] The description here is based on Honda PR materials.

the quality standards in product development, the company had previously adopted the same global Honda standards worldwide. Nevertheless, there had been a wide gap between the qualities of the products provided and that required in the Chinese market, and the company finally realized that Honda products had excessive quality for the market. As for the development of new models, the company sets the quality standards at the level that is required by customers and therefore aims at cutting costs by procuring from Chinese suppliers. Although the Honda standards will be maintained for the part consisting of "driving," "steering," and durability, the company considers active utilization of local suppliers for design parts.

Looking at another example, Yamaha Motors established the Yamaha Motors (Suzhou) in the industrial zone of Suzhou in Jiangsu province, a 100% investment, to make effective use of the location of China. This new company does not only selectively procure cheap and high quality parts from the Chinese local parts makers and the locally-operating Japanese parts makers, but also give instructions to the parts maker, once decided, to improve on their quality. Such parts will be used in the motorcycles that the company is to produce jointly with the Chinese local company. In addition, these will be supplied to the production bases overseas, including the one in Japan. The company thus aims to boost its competitiveness in each market of the world through active use of the Chinese cheap parts. Furthermore, this new company will bear the role to assist the development of low price and high quality new models that fit the Chinese market[4].

In September 2002, Suzuki established the Suzuki Motor R&D China Co., Ltd., specialized in the R&D of motorcycles in Jiangmen, Guangdong province, a new joint-venture with Jiangmen Dachangjiang Motorcycle Group, one of the largest motorcycle makers in China[5]. The purpose of the establishment is the promotion of product development and cost curtailment, aiming specifically at the swift development of motorcycles that satisfy the needs of the Chinese market. The company supplies its products for Jiangmen Dachangjiang Motorcycle Group, the counterpart of the joint investment and the technological alliance, as well as Jinan Qingqi Suzuki Motorcycle and Nanjing Jincheng Suzuki Motorcycle, which are both joint-ventures producing Suzuki motorcycles.

Thus, the Japanese makers have made expansions to the local market in various ways, and thereby prepared the systems in which the location-specific advantages in the local market are effectively incorporated in the corporate strategies. They are in pursuit of the advantages derived from the brand names that the Japanese makers had,

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[4] *Nikkan Jidousha Shinbun*, April 10, 2002.
[5] The description here is based on Suzuki PR materials.

while also utilizing the advantages based in China by letting the local entities take over the evaluation and management of suppliers in the quasi open architecture environment as well as the adaptation to the local quality standards. Information such as how the deals with the local suppliers are done, the senses for business speed, and the demand level for quality among the Chinese customers is the sticky information that cannot easily be obtained unless in China. Having the local bases is helping the Japanese makers to prepare the organizations to take advantage of such sticky information.

6. Conclusion

For industries or companies, product architectures have not been something given, but rather, from a historical point of view, they have shown a trend of cyclical changes between modular and integral types. The creation of new product architectures frequently accompany the formation of industrial clusters on the national or regional level, which is often promoted by the strategic group of companies that are regionally isolated. In this article, the development of the Chinese motorcycle industry was analyzed from the perspective of the changes in product architectures by different national clusters.

The changes in product architectures in the Chinese motorcycle industry appears almost identical to the coarse open / modular product architectures previously dominant in European regions in the first half of the 20th century, while on the other hand, they also show the aspect of complex architecture which differs from the above. Furthermore, it was observed that the official and unofficial systems of nation and regions affect the dynamism in the creation of architectures.

The discussion of this article remains at the exploratory stage. In order to further understand the phenomenon, in-depth case analyses and quantitative analyses with extensive samples are required. Regarding the interactions with the public systems in the development process of the Chinese companies, in particular, there is much left to be clarified, which should be the next step in our research effort.

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